

REMARKS

The Applicants thank the Examiner for the thorough consideration given the present application. Claims 5-11, 15, 18, 20, 23, and 35-38 were previously cancelled. Claims 1-4, 12-14, 16, 17, 19, 21, 22, 24-34 are pending, none of which is amended. Claim 1 is independent.

The Examiner is respectfully requested to reconsider the rejections in view of the remarks set forth herein.

Examiner Interview

If, during further examination of the present application, a discussion with the Applicants' Representative would advance the prosecution of the present application, the Examiner is encouraged to contact Carl T. Thomsen, Registration No. 50,786, at 1-703-208-4030 (direct line) at his convenience.

Rejections Under 35 U.S.C. §103(a)

Claims 1-4, 12-14, 16, 17, 19, 21, 24-26, 28-31, 33, and 34 stand rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al. (U.S. 4,283,228) and further in view of Fernandez et al. and Srivastava et al. (U.S. 5,433,917); claim 22 stands rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al., and further in view of Fernandez et al., Srivastava et al., and Maas et al;

claim 27 stands rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al., and further in view of Fernandez et al., Srivastava et al., and Yao et al.; and

claim 32 stands rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al., and further in view of Fernandez et al., Srivastava et al., and Chen et al.

These rejections are respectfully traversed.

Arguments Regarding Independent Claim 1 as Previously Presented

Independent claim 1 as previously presented recites a combination of steps directed to a method of producing a piezoelectric ceramic thick film on a substrate, said method comprising:

- mixing liquid phase precursors of Li₂O and Bi₂O₃ metal oxides to form a Li-Bi solution;
- forming a suspension of a piezoelectric ceramic material in powder form and a fluid medium by ultrasonic vibration;
- forming a liquid mixture by mixing the suspension of powdered material with the Li-Bi solution, the Li₂O and Bi₂O₃ having melting points lower than a temperature required for densifying the piezoelectric ceramic thick film by sintering, said liquid mixture obtained by mixing the suspension of powdered material and the Li-Bi solution having a greater degree of homogeneity than that of a mixture obtained by mechanically mixing the powdered material.

As the Examiner will note, independent claim 1 of the present invention sets forth “mixing liquid phase precursors of Li₂O and Bi₂O₃ metal oxides to form a Li-Bi acetic acid solution” during the preparation of the thick film paste, and thus to realize the homogeneous mixing of the glass-like binding agent and the piezoelectric powder.

On the other hand, in GB2161647, powder of glass-like binding agent was added to the piezoelectric ceramic powder (Pg 1, Line 98; Pg 2, Line 48). However, the homogeneity achieved through mechanically mixing the powder of the binding agent with piezoelectric ceramic powder is limited, particularly when the amount of the binding agent is small.

In Buchanan et al. (U.S. 4,283,228), when V₂O₅ are used as a sintering aid for the PZT powder, the PZT “was milled and blended with” V₂O₅ as dispersed in isopropyl alcohol (note V₂O₅ is dispersed, but not dissolved as in a real liquid phase). (Column 3, Lines 25-30.) This is merely dispersed solid particles, which is different from the real liquid phase precursor as set forth in independent claim 1. Although Buchanan et al. (U.S. 4,283,228) mentions ammonium vanadate, vanadyl salts, or V₂O₅-affording promoter generally (Lines 5-15 in Column 2, Line 25-35 in Column 4), these chemicals are simply intended to use as a source of V₂O₅ to react with PZT. However, Buchanan et al. do not disclose any process about how to take use of their liquid phase solution to realize a uniform mixing with PZT powder when the V₂O₅ is used as a sintering aid.

In addition, different compositions must be prepared using different chemicals to obtain stable solution or suspension system for realizing homogeneous mixing with the

piezoelectric powder. The V₂O₅ system of Buchanan et al. (U.S. 4,283,228) is different from Li, Bi and the corresponding metal organics and solvents.

Therefore, a combination of GB2161647 and Buchanan et al. (U.S. 4,283,228) do not cause the invention set forth in independent claim 1 to be obvious.

It should also be noted that Buchanan et al. (U.S. 4,283,228) merely deals with bulk ceramic processing, which is different from the thick film processing in the present invention. The ceramic powder used to prepare the paste for thick film printing in the present invention is different from that of Buchanan et al. (U.S. 4,283,228) for bulk ceramic. Only the present invention as set forth in independent claim 1 discloses that the metal organics as the sintering aids maintain their homogeneous distribution in the thick film paste system after the two mechanical millings, and quality thick film can be obtained through the printing and annealing of the ceramic paste. This has not been taught by any of the cited references. Prior to the disclosure of this invention as set forth in independent claim 1, there was no knowledge of how to prevent the out-separation of the metal organics of the sintering aid from the ceramic powder in the thick film paste with large amount of solvent due to their different specific weights during milling, or due to possible dissolution of the metal organics in the organic carrier for printable thick film paste.

Metal oxides of Li and Bi are previously used merely as sintering agents by forming liquid phase, but the liquid phase only forms during high temperature sintering process, (Srivastava et al. (U.S. 5,433,917 and Chen et al. "Dielectric, ferroelectric, and piezoelectric properties of lead zirconate titanate thick films on silicon substrate"). In these documents,

Li and Bi are always introduced as non-soluble oxide or salt by conventional mixing method, mechanical milling, with the piezoelectric ceramic powder. This is distinct from the features of independent claim 1 as previously presented, i.e.; “mixing liquid phase precursors of Li₂O and Bi₂O₃ metal oxides to form a Li-Bi acetic acid solution” during the preparation of the thick film paste. Thus, the Applicants do not agree with Item 6 of the Office Action from the Examiner. The Applicants believe that the Srivastava et al. (U.S. 5,433,917) document does not disclose anything regarding independent claim 1 as previously presented.

At least for the reasons explained above, the Applicants respectfully submit that the combination of method steps as set forth in independent claim 1 is not disclosed or made obvious by the prior art of record, including GB 2161647, Buchanan et al., Fernandez et al., and Srivastava et al.

Therefore, independent claim 1 is in condition for allowance.

Dependent Claims

All dependent claims are in condition for allowance due to their dependency from allowable independent claims, or due to the additional novel features set forth therein.

Accordingly, reconsideration and withdrawal of the rejections under 35 U.S.C. §103(a) are respectfully requested.

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CONCLUSION

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and that the present application is in condition for allowance.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, he is invited to telephone Carl T. Thomsen (Reg. No. 50,786) at (703) 208-4030(direct line).

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§1.16 or 1.17, particularly extension of time fees.

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Respectfully submitted,

By 
James M. Slattery #43,368
Registration No.: 28,380
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road
Suite 100 East
P.O. Box 747
Falls Church, Virginia 22040-0747
(703) 205-8000
Attorney for Applicant

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